MOTORIZED BRACELET ASSEMBLY FOR MOVING SENSOR MODULES AROUND A PIPE

FIELD OF THE INVENTION

The present invention relates to pipe inspection equipment and more particularly to a bracelet assembly for moving sensor modules around a pipe, for example for ultrasonic crack detection in pipes used in nuclear power plants.

BACKGROUND

The international patent application published on July 29, 2004 under no. WO 2004/063660 (Lavoie) discloses a motorized bracelet assembly used to move sensors along a pipe. The bracelet assembly has a frame installable around a pipe and a support device holding the sensors. The frame has wheels for moving the frame in an axial direction of the pipe. A flexible transmission device receives a rotational movement and transmits it to a gear box mounted on the frame. The gear box re-directs the rotational movement from the flexible transmission device towards the wheels. This motorized bracelet facilitates the inspection of the thickness of nuclear pipes with respect to the manually displaceable bracelet assembly disclosed in international patent application published on December 2001 under no. WO 0196808 (Lavoie). However, this motorized bracelet assembly is not adapted for crack detection in the pipes. For crack detection, the sensors must be positioned and moved in periphery and in an axial direction of the pipe while being held at an angle with respect to the surface of the pipe. However, none of the bracelet assemblies known in the art is able to achieve such a positioning and displacement of the sensor modules in periphery of the pipe.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a bracelet assembly for detecting cracks and other possible types of flaws in a pipe.

Another object of the present invention is to provide such a bracelet assembly for detecting cracks and other possible flaws near a dimensional change of a pipe.

Another object of the present invention is to provide such a bracelet assembly, which is versatile and which can be used for other types of operations on a pipe.

According to the present invention, there is provided a bracelet assembly for moving sensor modules around a pipe, comprising a frame adapted for installation around the pipe, supports adapted to receive the sensor modules, a sliding arrangement slideably mounted onto the frame and guiding a displacement of the supports in periphery of the pipe, the sliding arrangement comprising attachments spaced apart from one another and receiving the supports in periphery of the pipe, a first driving means for controllably driving the sliding arrangement and thereby displacing the supports in periphery of the pipe at desired operating positions, biasing means for biasing the sensor modules against the pipe, wheel arrangements distributed around the frame and projecting therefrom for engagement with the pipe and displacement of the frame along an axial direction of the pipe, and a second driving means for controllably driving the wheels in rotation and thereby displacing the frame along the axial direction of the pipe at a desired operating position.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the invention will become apparent upon reading the detailed description and upon referring to the drawings in which:

Figure 1 is a perspective view of a bracelet assembly with inside sensor modules according to the present invention.

Figure 2 is a perspective view of a sliding arrangement of a bracelet assembly according to the present invention.

Figure 3 is a perspective view of a support for sensor modules according to the present invention.

Figure 4 is a perspective view of a reciprocating arrangement of a bracelet assembly according to the present invention.

Figure 5 is a perspective view of another bracelet assembly with outside sensor modules according to the present invention.

Figure 6 is a perspective view of a sliding arrangement of a bracelet assembly of the type shown in Figure 5.

Figures 7, 8 and 9 are perspective views of support assemblies for a bracelet assembly of the type shown in Figure 5.

Figure 10 is a schematic view of an ultrasonic beam traveling within a wall of the pipe.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figures 1 and 2, there is shown a bracelet assembly 2 according to the present invention, for ultrasonic inspection of pipes, such as the pipe 50 shown in Figure 10, used for example in CANDU power plants. The bracelet assembly 2 may also be used for inspection of other types of pipes which are hard to reach or for any other pipes where motorized inspection is desired. The bracelet assembly may be adapted for specific inspection needs, such as inspection of graylock welds, 360 degrees inspection of the pipes, etc.

The bracelet assembly 2 has a frame 6 adapted for installation around the pipe. The frame 6 has a pair of circular members 8,10 spaced apart from each other, so that the frame 6 exhibits a circular shape. The shape as such of the frame 6 is not critical, provided that it takes little space and is installable around the pipe (at least over a major part of its perimeter, unless a special attachment is used to

hold the bracelet around the pipe). Preferably, the shape of the frame 6 adapts to the shape of the pipes, especially at the level of an elbow section of the pipe where the pipe may have an oval shape.

A sliding arrangement 12 (better shown in Figure 2) is mounted onto the frame 6 for slideably guiding supports 16 along a peripheral course 20 around the pipe. The slidings arrangement 16 has attachments 25 spaced apart from one another and receiving the supports 16 in periphery of the pipe. As illustrated, the sliding arrangement 12 has a slideable member 18 having a pair of curved arms 22,24, so that to the slideable member 18 exhibits a hoop shape. The curved arms 22,24 are spaced from one another and extend between the circular members 8,10 of the frame 6.

Pins 34 projecting from each ends of the curved arms 22,24 engage in grooves 36 extending concentrically with respect to the peripheral course 20 on opposite facing sides of the circular members 8,10. The grooves 36 are used as a guide member receiving the slideable member 18 for sliding along a predetermined sliding range of the peripheral course 20. A projecting flange (not shown) extending concentrically with respect to the peripheral course 20 on each of the curved arms 22,24 may also be used instead of the pins 34 to engage the grooves 36.

It is worth noting that the pins 34 may instead be located on the circular members 8,10 and the grooves 36 may be located along a length of the curved arms 22,24.

As illustrated in Figure 3, sensor modules 26 are supported by a pair of arms 28,30 connected to a common pivot point, such as formed by an elongated connecting rod extending transversally between the curved arms 22,24 and providing the pins 34.

Referring back to Figure 2, although the pins 34 are conveniently extensions of the connecting rod, they could be located at different positions along the length of the curved arms 22,24 if desired.

As shown in Figures 1 and 2, a first driving device formed of a driving pinion 38 mounted onto the frame 6 and engaging with an elongated rack 40 extending along a length of the slideable member 18, controllably drives the sliding arrangement 12 to move the supports 16 in periphery of the pipe at desired operating positions. Together, the pinion 38 and the rack 40 form a rack-and-pinion gear operable for producing a reciprocating motion of the sensor modules 26 along the peripheral course 20.

Referring again to Figure 3, the sensor modules 26 may be formed of wedges 42 and ultrasonic transducers 44 used to detect cracks and flaws in the pipe. The transducers 44 are mounted on the wedges 42 at a predetermined angle with respect to the peripheral surface of the pipe to guide ultrasonic beams 48 of the transducers 44 into the wall 50 of the pipe, as shown in Figure 10. The wedges 42 may be arranged to guide the ultrasonic beams 48 at other angles within the wall 50 of the pipe. The wedges 42 have bottom surfaces 52 matching an outer peripheral surface of the pipe and they are pivotally attached to the pair of arms 28,30.

Referring to Figures 1 to 3, in the illustrated case, there are two pairs of sensor modules 26 connected to the slideable member 18 through the supports 16 located at each end of the slideable member 18. Each pair of sensor modules 26 is formed of two wedge and ultrasonic transducer assemblies pivotably mounted next to each other on the pair of arms 28,30 of the supports 26. The two assemblies are mounted in a back to back type of configuration to direct their respective beam in opposite directions. The driving pinion 38 (shown in Figure 2) drives the slideable member 18 along the peripheral course 20 to cover the circumference of the pipe.

To insure that the sensor modules 26 stay in contact with the peripheral surface of the pipe, the wedges 42 of a same pair of sensor modules 26 are linked together by a return spring element 56 located at a lower level than the connecting rod, thereby pushing the wedges 42 against the peripheral surface of the pipe.

Referring to Figure 4, there is shown a bracelet assembly 2 in which the supports 16 are in the form of reciprocating arrangements guided by the sliding arrangement 12 for oscillation along the peripheral course 20. In the illustrated case, the first driving device has rotating shafts 58 mounted on the frame 6 and linked together, e.g. with a linking belt (not shown). The supports 16 have ends provided with connecting rods 60,62 pivotably attached to the rotating shafts 58. The rotary shafts 58 produce reciprocating motions of the supports 16, as required for crack detection.

Referring to Figures 5 and 6, there is shown another bracelet assembly 2 according to the present invention, which is particularly adapted for inspection near a weld or other dimensional change in the pipe. In this bracelet assembly 2, the slideable member 18 extends on a guide member 19 (better shown in Figure 6) mounted on a front side of the frame 6 around the pipe. The slideable member 18 exhibits a hoop shape. One support 16 is mounted at each end of the slideable member 18 and extends away from the front side of the frame 6. The sensor modules 26 may be located at an angle of 180 degrees from each other. According to the configuration of the sliding arrangement 12, the slideable member 18 can rotate 180 degrees around the pipe to allow the sensor modules to cover all the circumference of the pipe. It is worth noting that the bottom surfaces 52 of the wedges 42 are contoured to match the peripheral surface of the pipe.

As previously mentioned, the bracelet assembly shown in Figures 5 and 6 is suitable for detection near a weld since the sensor modules 26 are extending away from the frame 6 and not between the frame 6, as shown in Figure 1. The sensor modules 26 may thus be positioned closer to the feature to inspect.

The supports 16 may be mounted at different positions along the length of the slideable member 18. Mounting brackets 60 may be used to fasten the supports 16 to receiving surfaces 62 extending along the length of the slideable member 18. As shown in Figures 7 to 9, the receiving surfaces 62 may also project from a front side of the slideable member 18. The mounting brackets 60 may be fastened to the receiving surfaces 62 by screws or other kinds of fasteners if desired.

Referring to Figures 7 to 9, various types of supports may be used with the bracelet assembly shown in Figures 5 and 6. For example, these supports may comprise a pair of arms 70 pivotally mounted to the mounting brackets 60. The sensor modules 26 extend between the pair of arms 70. Instead of using return spring element 56 to bias the wedges 42 against the surface of the pipe, torsion springs 72 extend between the mounting brackets 60 and the pair of arms 70 to keep the wedges 42 against the surface of the pipe. As illustrated, the supports 26 may be adapted to direct the ultrasonic beams 48 in different directions within the wall 50 of the pipe to detect axial and/or circumferential cracks. Of course, any other suitable combination of these supports 16 may also be used.

In all the illustrated bracelet assemblies 2, the frame 6 is provided with wheel arrangements 90 distributed around the frame 6 and projecting therefrom for engagement with the pipe and displacement of the frame 6 along the axial direction of the pipe. The wheel arrangements 90 may be as the ones described in the international patent application no. WO 2004/063660 (Lavoie).

A second driving device, such as a flexible transmission device 91, as shown in Figure 1, drives the wheel arrangements 90 in rotation to move the frame 6 along the axial direction of the pipe at a desired operating position. The flexible transmission device 91 may receive a rotational movement and transmit it to a gearing device 92 mounted onto the frame 6. The gearing device 92 re-directs the rotational movement from the flexible transmission device towards the wheels

The wheels 90 may be magnetized to insure good traction on the pipe and to help keeping the bracelet assembly 2 in position around the pipe in presence of slippery couplant.

One of the advantages of the bracelet is that it may be easily installed and uninstalled around the pipes.

Although preferred embodiments of the present invention have been described in detail hereinabove and illustrated in the accompanying drawings, it is to be understood that the invention is not limited to these precise embodiments and that various changes and modifications may be effected therein without departing from the scope or spirit of the present invention.

Furthermore, as shown in Figure 1, a closing device may be mounted between two open ends 80,82 of the frame 6 to fasten the bracelet assembly 2 around the pipe. The closing device may be formed of a pair of legs 84, 86 pivotally connected respectively to the open ends 80,82 of the frame 6, and forming complementary extensions thereof. Although not illustrated in Figure 1, the legs 84,86 may also be connected with each other by a spring element or any other suitable fastener. The closing device may be manually operated and is preferably straightforward to operate, thus requesting very few manipulations from an operator. Other closing devices, such as the ones shown in Figures 4 and 5, may be used instead. Also, the bracelet assembly could be made of flexible material so that no closing devices would be needed.

Moreover, instead of a wedge and ultrasonic transducer assembly, the sensor modules may be formed of a non-sensing tool or device, such as an abrasive tool used to process the surface of the pipe. The expression "sensor module" has been used herein for sake of simplicity. But it should be construed as including non-sensing modules as mentioned above.

The compact configuration of bracelet assembly 2 allows it to be used in cramped space.